Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	**)**	
Expanding the Economic and Innovation Opportunities	**)**	**Docket No. 12-268**
of Spectrum Through Incentive Auction	**)**	
Revisions to Rules Authorizing the Operation of Low Power	**)**	**WT Docket No. 08-166**
Auxiliary Stations in the 698-806 MHz Band	**)**	
Public Interest Spectrum Coalition, Petition for Rulemaking	**)**	**WT Docket No. 08-167**
Regarding Low Power Auxiliary Stations, Including Wireless	**)**	
Microphones, and the Digital Television Transition	**)**	
Amendment of Parts 15, 74 and 90 of the Commission's rules	**)**	**ET Docket No. 10-24**
Regarding Low Power Auxiliary Stations, Including Wireless	**)**	

COMMENTS OF THE CONSUMER FEDERATION OF AMERICA

TABLE OF CONTENTS

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OVERVIEW OF FINDINGS

In these comments, the Consumer Federation of America highlights and updates key findings from our 2011 study entitled *Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves.* The bottom line is clear; the case for expansion of spectrum dedicated to unlicensed use is stronger than ever.

Dramatic offloading of cellular broadband traffic and the extension of fixed broadband traffic to wireless devices have placed unlicensed spectrum at the center of the broadband ecology.

- In the United States, at least 80% (although likely as much as 90%) of the increase in mobile data traffic between 2010 and 2012 relied on unlicensed spectrum to provide end-user connectivity because cellular providers found that offloading their broadband traffic onto unlicensed spectrum was less costly and more efficient than building more cell sites.
- Today, unlicensed spectrum carries traffic to end users that equals two-thirds of cellular licensed broadband and is expected to grow to four-fifths of total cellular traffic in the decade ahead.

Yet, the greatest growth in the use of unlicensed spectrum did not come from offloading cellular traffic. It came from extending fixed, broadband service to user defined networks.

- The proliferation of user-deployed devices equipped with protocols (e.g. Wi-Fi, Blue Tooth, etc.) that utilize unlicensed spectrum has enhanced the value of all broadband by delivering it to users on ubiquitous home and office networks.
- In 2011, one-third of fixed Internet broadband traffic flowed through unlicensed spectrum and that figure is expected to grow to one-half in the decade ahead.

Prospects for a dramatic increase in demand for new types of services are strong.

- New functionalities, like end-to-end security, personalized, flexible access, venue-based analytics and advertising, optimized resource allocation, and seamless roaming can provide the basis for new connectivity and network management services.
- These will meet the need of nascent types of demands generated by the Internet of Things and nomadic consumers, who move from place-to-place, but are stationary when they send and receive data.
- Dedicating spectrum for unlicensed use in the TV bands is important to ensure that it can continue to efficiently support services that meet the increasingly diverse needs of the expanding the Internet of Things and allow hotspots to grow into hot zones, creating ubiquitous networks of oases to serve nomadic uses.

The massive offloading of traffic onto unlicensed spectrum reflected two factors, the superiority of the unlicensed model and the weaknesses of the licensed model.

- Unlicensed spectrum has become this focal point of broadband development because it is less costly to roll-out hot spots than cell sites, scales rapidly, promotes self-provision of networks, has higher throughput, uses devices that consume less battery power, and, given their origin in unlicensed space, are better equipped to handle interference, which is becoming a bigger problem as spectrum usage increases.

- The spectrum crunch that has motivated the auction frenzy is, to a significant extent, the result of several weaknesses in the cellular licensed model – the failure to deploy network infrastructure, optimize utilization of network resources and deploy advance end-user receivers that can cope with interference.

Setting aside spectrum for unlicensed use is the single best way to accomplish the goals of reforming the use of broadcast TV spectrum, because it ensure a much greater amount of economic activity in the wireless broadband space, which creates larger federal revenue.

- Valuing the economic activity that takes place in unlicensed spectrum at observable prices for equivalent standalone services we place its total value well in excess of $36 billion.
- The efficiency gains that unlicensed sharing of spectrum delivers within the wireless sector and throughout the economy by advancing the Internet of Things is at least as large as the direct value of use of unlicensed and will grow exponentially over the next decade.
- Use of unlicensed spectrum lowered the cost of cellular broadband service substantially, with savings on the order of $20 billion per year, which is a substantial savings in a market with annual revenues of $70 billion.

Setting aside spectrum for unlicensed use is not likely to reduce auction revenues for several reasons.

- If the supply of spectrum for exclusive licenses at auction is reduced, the cellular providers will bid up the price of the spectrum that is auctioned, substantially if their claim of a "spectrum crunch" is to be believed.
- Because licensed and unlicensed have strong complementarity, the availability of unlicensed increases the value of licenses.
- In most cases, users of unlicensed spectrum share the spectrum with primary users

The economic value generated by unlicensed spectrum is so large that, even if setting aside spectrum for unlicensed use reduced auction revenue by a small amount, the general revenues associated with the vastly greater amount of economic activity would offset the loss in a very short period of time.

- Based on total revenues, the value of federal tax revenue generated by wireless activity equaled about $45 billion per year. The share that would be attributed to unlicensed is about $11 billion.
- Given the outcomes of recent auctions, the tax revenue generated by the activity in unlicensed spectrum would make up for the decisions to dedicate spectrum to unlicensed (and withhold it from auction) in a matter of weeks or months.

I. BACKGROUND

A. COMMENTERS

The Consumer Federation of America is pleased to submit these comments in response to the Notice of Proposed Rulemaking[1] and the Public Notice[2] in the above captioned proceeding. The Consumer Federation of America (CFA) is an association of non-profit consumer organizations that was established in 1968 to advance the consumer interest through research, advocacy, and education. Today, nearly 300 of these groups participate in CFA and govern it through their representatives on the organization's Board of Directors and the annual Consumer Assembly. CFA has been involved in communications, media and Internet policy for decades in legislative, regulatory and judicial arenas and has advanced the consumer view in policy and academic publications.[3]

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[1] In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, Notice of Proposed Rulemaking, FCC 12-118, Docket No. 12-268 (rel. Oct. 2, 2012)(hereinafter "Incentive Auctions NPRM" or "NPRM"). By Order dated November 29, 2012, the Commission extended the deadline for filing initial Comments to January 25, 2013. See Order, DA 12-1916, Docket No. 12-268 (rel. Nov. 29, 2012).

[2] Public Notice, The Wireless Telecommunications Bureau and the Office of Engineering and Technology Seek to Update and Refresh the Record in the Wireless Microphones Proceeding, DA 12-1570, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (rel. Oct. 5, 2012). By Order dated November 30, 2012, the Commission extended the deadline for filing initial Comments to January 25, 2013. See Order, DA 12-1926, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (rel. Nov. 30, 2012).

[3] Mark Cooper, Once Money Talks, Nobody Else Can: The Public's first Amendment Assets Should Not Be Auctioned to Media Moguls and Communications Conglomerates," In the Matter of Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policy, Federal Communications Commission, DA 02-1221, ET Docket No. 02-135, July 8, 2002; "The Political Economy Of Spectrum Policy: Unlicensed Use Wins Both The Political (Freedom Of Speech) And Economic (Efficiency) Arguments," *Spectrum Policy: Property Or Commons*? Stanford Law School, March 1, 2003; "Spectrum as Speech in the 21st Century*," The Public Airwaves as a Common Asset and a Public Good: Implications for the Future of Broadcasting and Community Development in the U.S.,* Ford foundation, March 11, 2005; "The Economics of Collaborative Production in the Spectrum Commons," *IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks,* November 2005; "From Wifi to Wikis and Open Source: The Political Economy of Collaborative Production in the Digital Information Age," *Journal on Telecommunications and High Technology Law,* 5:1, 2006; "Governing the Spectrum Commons," September 2006. *Telecommunications Policy Research Conference,* October 2006; "The Central Role of Wireless in the 21st Century Communications Ecology: Adapting Spectrum and Universal Service Policy to the New Reality," *Telecommunications Policy Research Conference*, September 2011.

B. Purpose

A year ago the Consumer Federation of America published an extensive analysis of the development of the utilization of unlicensed that demonstrated that huge economic benefits had been created by the decision to allow unlicensed use of selected frequencies in the radio spectrum.[4] It showed that the commercial potential and technological capability exists for a dramatic expansion of the economic output of the unlicensed sector in the next decade, but that growth would be stunted and undermined if additional spectrum is not made available for unlicensed use. The obvious policy conclusion that flowed from the analysis is that additional spectrum should be made available for unlicensed use.

The legislation authorizing the use of incentive auctions to repurpose and restructure radio frequencies that have heretofore been dedicated to licensed over-the- air television broadcasting allows the Federal Communications to expand unlicensed use.[5] The Notice of Proposed Rulemaking to implement the incentive auction includes a number of measures to do so, yet, there continues to be resistance to setting aside more spectrum for shared use from those who focus on short term revenues from the auctioning of spectrum, rather than the much larger, long term stream of revenue that would result from the dramatic expansion of commerce in the unlicensed space.

Developments in the wireless communications sector in the past year not only reinforce our earlier conclusion, they suggest that our estimates of the economic benefits of unlicensed use were too low. These comments briefly review our earlier report on unlicensed spectrum, which is attached as Appendix A to these comments. We discuss data on the performance of licensed and unlicensed spectrum from the past year and review additional analyses that have come to light since our earlier report. Detailed analysis of the specific proposed rules and procedures that are consistent

[4] Mark Cooper, *Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves: The Dramatic Success of Combining Market Principles and Shared Access*, Consumer Federation of America, January 2012. Attached as Appendix.
[5] Title VI of the Middle Class Tax Relief and Job Creation Act of 2012 §§6001-6073 (the Spectrum Act)

with the findings of this analysis are presented in the comments of Public Interest Spectrum Coalition, of which CFA is a member.

II. The factors Underlying the Success of the Unlicensed Model

Before we launch into a review of the numbers, it is important to have in mind the institutional and policy basis for the remarkable success of the unlicensed model. The success of the unlicensed model results from the entrepreneurship and innovation that was unleashed by the radically deregulatory, procompetitive decision by the Federal Communications Commission (FCC) to make an essential input widely available to new entrants into the communications market.

A. Unlicensed Spectrum: A Radical Free Market Approach to Spectrum Use

In the early days of radio communications, policymakers chose to manage interference in radio transmission by granting an exclusive license to one user to transmit signals on specific frequencies, called bands, in a specific geographic area for a specific purpose. For three quarters of a century this approach led to the dominance of broadcasting in the commercial use of the airwaves. In the mid-1980s the Federal Communications Commission (FCC) altered the regulatory regime for access to spectrum and created the opportunity for dramatic improvements and changes in the use of spectrum for communications purposes. [6]

The FCC established the basis for two different approaches. Exclusive licenses were made available to allow new, two-way communications, and later, licenses were auctioned to the highest bidder.[7] The licenses were still exclusive, but the bidding and flexibility were intended to improve the utilization of spectrum by assigning the rights to those who were willing to pay the highest price. At the same time, the FCC identified some bands where there would be no licensee and interference would be avoided by the use of new technologies (spread spectrum) and restrictions on the amount

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[6] Kevin Werhbach, *Radio Revolution: The Coming Age of Unlicensed Wireless,* New America Foundation, Public Knowledge.

[7] The first two licenses were given to incumbent wireline telecommunications providers.

of power devices could use.[8] Anyone and everyone could transmit in these unlicensed bands as long as the devices obeyed the rules.

The original approach to interference management through spectrum allocation and the two new approaches have been described in a number of ways – command and control v. property v. commons;[9] administrative v. tradable/flexible/market-oriented v. license exempt commons.[10] However, the simple labels do not do justice to the differences and similarities between the models. For example, it can be argued that the license-exempt approach is more market-oriented than the tradable/flexible exclusive licensed approach because it invites much greater entry and competition at the device and service levels. At the same time, the license-exempt model is far from a free-for-all, since the FCC certifies devices that must comply with very specific rules for their operation (in effect "licensing" devices rather than uses or users). Indeed, the FCC still administers the regime of rights enjoyed by spectrum users under both of the newer models.

The labels – with the intense ideological baggage they carry and rhetorical combat they inspire – are less important than the incentives the models provide and the economic performance that they achieve. [11] In fact, it can be argued that the labels have become a hindrance to clear analysis

[8] Wolter Lemstra, Vic Hays and John Groenewegen, (Eds.), *The Innovation Journey of Wi-Fi: The Road to Global Success,* Cambridge: Cambridge University Press Lynn, 2011, , p. 4, "Moreover, the example set by the FCC in the assignment of radio frequency bands for use by radio LANS has been followed by assignments by national regulatory agencies in the countries of Europe and Asia, including Japan, South Korea, India and China, thereby creating a global market for Wi-Fi products."

[9] Kenneth R. Carter, "Policy Lessons from Personal Communications Services: Licensed vs. Unlicensed Spectrum Access," *Commlaw conspectus,* 15 (2006).

[10] Robert Horvitz, Beyond Licensed v. Unlicensed: Spectrum Access Rights Continua, ITU, January, 2007,p.1, "It is widely accepted today that there are three main approaches to radio spectrum management: The traditional "administrative" approach, in which a regulator decides who can use what frequencies for what purposes in what locations under what conditions: The newer "tradable/flexible/market-oriented" approach, in which those who are authorized to use spectrum are allowed to re-purpose or transfer some or all of their rights. Tenders or auctions are typically used for the initial distribution of rights. "License-exempt commons" in which any number of users are allowed to share a band with no right of non-interference and no right to cause interference."

[11] The debate between licensed and unlicensed spectrum frequently plays out, in footnotes at least (see e.g. Richard Thanki, The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum, Perspective, 2009,), as a debate between two Nobel laureates in economics. On one side is Ronald Coase, whose 1959 essay

and policy recommendations. Fortunately, the theoretical/theological debate has been rendered moot by empirical reality. In a little more than a decade, the two institutional arrangements have come to stand side-by-side in remarkable balance and symbiosis.

B. THE INGREDIENTS OF SUCCESS

The unlicensed model succeeded because it provided access to a vital input that allowed entrepreneurs to invest in products and services that people value. In order to utilize the unlicensed spectrum, device manufacturers must design, build and market devices that consumers buy. To induce consumers to do so, useful applications must be written and distributed. Hundreds of thousands of base stations must be deployed and consumers or service providers must pay for the transport of traffic to and from the Internet. The unlicensed model succeeded because removing the spectrum barrier to entry decentralized decision making, deconcentrated investment, promoted

highlighted the inefficiency of the licensing scheme at the FCC and is taken to be an argument for auctioning spectrum by neoclassical economists. On the other side is Eleanor Ostrom (Elinor Ostrom, Beyond Markets and States: Polycentric Governance of Complex Economic Systems, Prize Lecture, December 8, 2009), whose work has demonstrated that efficient and effective non-property approaches to management of common pool resources are possible. Defenders of the unlicensed model claim Coase for their own, however, by arguing that a change in technology that significantly altered transaction costs could easily lead to a different conclusion about the relative merits of different institutional arrangements (Yochai Benkler, "Overcoming "Agorphobia: Building the Commons of the Digitally Networked Environment," Harvard Journal of Law and Technology, 11, 1998, Yochai Benkler, "Some Economics of Wireless communications," Harvard Journal of Law and Technology, 16 (2000): Ryan, 2005, Patrick Ryan, "Questioning the Scarcity of Spectrum: The Structure of a Spectrum Revolution," Journal of Internet Law, March, 2005; The New Institutional Economics accommodates both possibilities by focusing on institutions as one, critically important element of economic structures, along with transaction costs and technology. As Douglas North (Institutions, Institutional Change and Economic Performance, Cambridge University Press, 1990, p. 118), another Nobel Laureate, put it, "Institutions provide the basic structure by which human beings throughout history have created order and attempted to reduce uncertainty in exchange. Together with the technology employed, they determine transaction and transformation costs and hence the profitability and feasibility of engaging in economic activity. (p. 118)." This is consistent with North's view that Coase's argument can lead to a fundamental critique of neoclassical economics (Douglas North, "Economic Performance Through Time," Prize Lecture, December 9, 1993, "It was Ronald Coase (1937 and 1960) who made the crucial connection between institutions, transaction costs and neo-classical theory; a connection which even now has not been completely understood by the economics profession. Let me state it baldly. The neoclassical result of efficient markets only obtains when it is costless to transact. When it is costly to transact, institutions matter. And because a large part of our national income is devoted to transacting, institutions and specifically property rights are crucial determinants of the efficiency of markets. Coase was (and still is) concerned with the firm and resource allocation in the modern market economy; but his insight is the key to unraveling the tangled skein of the performance of economies over time, which is my primary concern.") The critique of the neoclassical model by the New Institutional Economics school is discussed in depth in Mark Cooper: "Why Growing Up is Hard to Do: The Quarterlife Crisis of the Digital Revolution," Journal of Telecommunications and High Technology Law, Vol. 10, No. 2, 2013 an end-user focus, allowed user innovation and lowered transaction costs. This brought new and unique services to market, increased the value of broadband by extending it to new devices, and provided a lower cost, more efficient avenue to deliver data to consumers.

Traditional Economic Factors

From the point of view of traditional economic analysis, compared to exclusive licenses, the unlicensed model is extremely, even radically, deregulatory.[12] It captures what would be externalities with respect to licensed approaches.[13]

- The unlicensed model removes the spectrum barrier to entry, which is the primary obstacle by allowing anyone to transmit signals for any purpose, as long as the devices used abide by the rules.[14]
- Removing this barrier to entry removes the threat of hold up, in which the firm that controls the bottleneck throttles innovation by either refusing to allow uses that are not in its interest, or appropriating the rents associated with innovation.[15]
- It lowers the hurdle of raising capital, by eliminating the need for a network and focusing on devices.[16]
- It fosters an end-user focus that makes innovation more responsive to consumer demand; indeed, it allows direct end-user innovation.[17]

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12 Horvitz, 2007, p. 4, Market forces obviously operate in license-exempt bands even without spectrum pricing – through equipment purchase decisions by countless individuals at the retail level and through manufacturers' product development and marketing decisions at the wholesale level. Regulatory criteria for equipment type acceptance constrain these forces – though not as much as license conditions limit the choices of purchasers, designers and producers of radio equipment for licensed use. In that sense, license-exempt bands are arenas for more creative competition among equipment vendors and service providers than the licensed bands."

13 Paul Milgrom, Jonathan Levin and Assaf Eilat, *The Case for Unlicensed Spectrum,* October 12 , 2011, p 2, [T]he primary benefits of unlicensed spectrum may very well come from innovations that cannot be yet be foreseen. The reason is… that unlicensed spectrum is an enabling resource. It provides a platform for innovation upon which innovators may face lower barriers to bringing new wireless products to market, because they are freed from the need to negotiate with exclusive license holders."

14 Horvitz, 2007.

15 Milgrom, et. al., 2011, p. 13.

16 Lemstra and Groenwegen, 2011b, p. 373, "Multiple product vendors and, later, service providers have been seen to be willing to invest in the development of products and service to exploit the unlicensed part of the RF spectrum." One could argue that this is the result of the return on investment largely being based on the sale of Wi-Fi equipment, and not on the exploitation of a service requiring complementary and deep investment in the creation of a network infrastructure, as is the case in mobile cellular communications."

- It de-concentrates the supply of services compared to the exclusive licensed model, especially for high bandwidth services which tends to result in a very small number of suppliers, particularly in lower density markets.[18]

Unlicensed spectrum lowers transaction costs. If the rules are written leniently, many people will be able to transmit for many purposes. If the rules are written well, interference will be avoided. The FCC's approach to setting aside spectrum for shared use exhibits several characteristics that accomplish the task of managing the common pool resources in a light handed manner. [19]

- The use rules were simple and established an easy set of conditions with which devices had to comply.
- They did not require intensive, continuous monitoring and coordination.
- There were no membership rules. Anyone could enter and use the shared resource.

Systemic Diversity

Beyond these traditional economic factors, the unlicensed model creates a much more diverse sector. Diversity has come to be recognized as a uniquely important characteristic of economies and economic systems because it reinforces desirable economic traits of the system.[20] Diversity creates value, enhances innovativeness and builds resilience, as well as promoting other social values like pluralism. Diversity is created by three systemic characteristics – variety (the number of firms), balance (market shares of firms) and disparity (the differences between the firms).

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17 Eric Von Hipple, *Democratizing Innovation*, Cambridge, MIT Press, 2005, has emphasized the importance of user innovation. Cooper, 2006, discusses the importance of end-user innovation and local knowledge in collaborative production in digital product spaces, including Wi-Fi and mesh networking.

[18] The intensity of the debate over ownership models is equaled or exceeded by the intensity of the debate over whether the dramatic increase in concentration of the cellular service sector has resulted in the abuse of market power. Cooper, 2011,, shows that economies of scale and scope and industry concentration have both typified the decade of development of wireless broadband, making it difficult, if not impossible, to disentangle the two.

[19] Cooper 2005, applied the framework developed by Ostrom to mesh networks, discussing the eight sets of rules that have been identified. The FCC boiled the management challenge down to primarily one set of rules – position rules that define what users of the resource are allowed to do. Milgrom, et al. (p. 14), describe the FCC approach to shared public use spectrum as a "managed commons. " In fact, it has succeeded because it relies on as little management as possible to get the job done.

[20] Andrew Stirling, *On the Economics and Analysis of Diversity* (Science Policy Research Unit, University of Sussex, 2000, Francoise Benhamou, Reanto G. Flores, Jr. and Stephanie Peltier, *Diversity in Cultural Economics: Theoretical and Empirical Considerations*, Granem, Universite Angers, September, 2009.

Adding an additional cellular service provider may increase variety and may improve balance if the new provider gains market share, but it does not increase disparity. The diversity that a different ownership model introduces into the communications ecology provides the uniquely significant benefit of introducing a different perspective that is ideal for enhancing diversity.[21]

C. Recognizing the Policy Implications of the Success of the Unlicensed Model

The dramatic developments in the wireless sector in the past decade and the success of the unlicensed model have been so swift and unexpected that their implications for policy have not been fully recognized. Ironically, the success of the unlicensed model has not been studied rigorously by the agency that made it possible. The counts of subscribers that are used to demonstrate the success of mobile communications and that receive the overwhelming attention of regulatory bodies and agencies focus almost entirely on cellular services offered by holders of exclusive licenses. The FCC publishes annual reports on the Commercial Mobile Radio Service market[22] and semi-annual reports

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[21] It is important to note that the benefit of diversity in ownership models in the digital age is not limited to the example of spectrum reserved for or made available to shared use by the public. In fact, we find a similar outcome across a number of areas of the digital economy. Cooper, 2006, Wi-Fi to Wikis, analyzes several examples. In software development, proprietary and open source software have both grown side-by-side. Sometimes they reinforce one another, as in the extensive support provided to open source projects by proprietary software firms. Sometimes they compete, as in the rivalry between Microsoft, Apple and Linux in operating systems or Apple and Android in the mobile operating system product space. In the desktop computing product space, the PC open platform and the Apple closed platform have existed side-by-side for decades. When the smaller, closed platform ultimately supported the larger open platform it gained substantial market share, creating more balance. In the production and distribution of content, peer-to-peer networks exist alongside hub-and-spoke networks and are used to alleviate congestion on or efficiently manage the resource of those networks (Cooper, Cooper, 2011, "Structured Viral,). The real world experience during the past quarter century (which is roughly the first quarter century of the digital revolution) strongly supports the conclusion that diversity of business models and ownership approaches creates an environment that stimulates economic growth and dynamic innovation. While collaborative production based on non-property exploitation of common pool resources has long coexisted with the private exploitation of resources, the two ownership models tended to occupy very different spaces and the collaborative model has played a much smaller role in industrial society. Digital technology seems to be supporting a broader role for collaborative production. Digital technologies enable the embodiment of knowledge in silicon chips, which facilitates the decentralization of intelligence and promotes distributed innovation. Digital communications dramatically lower the cost of communications, which enhances coordination as a result. The digital revolution has fostered the convergence of areas in which the two models can exist side-by-side and expanded the role of collaborative production.

[22] FCC, Commercial Mobile Radio Services (CMRS) Competition Report, annual.

on mobile and wireline broadband adoption,[23] but it does not produce any regular reports on the use or development of unlicensed spectrum. Indeed, it has never conducted a comprehensive, rigorous examination of the performance of the unlicensed sector. In a deregulatory age one of the most successful experiments in radical deregulation has received almost no analytic attention from the FCC.

The dramatic success of the unlicensed model in the past decade and its potential to replicate and expand continues to be ignored by advocates of the licensed model. For example, an analysis by Thomas Hazlett,[24] one of the most vociferous opponents of the unlicensed use model,[25] provides a case in point. He frames the analysis not in terms of whether unlicensed has succeeded, but whether it has reduced the case for exclusive licensed model.

> Here, the question is: Have advanced technologies, yielding enhanced opportunities for wireless activities to be coordinated by smart technology, reduced the case for exclusive spectrum rights? In a word, *no.*[26]

Hazlett then offers an "acid" test by which to evaluate ownership models.

> If technologies operating on unlicensed bands were actually disruptive to the logic of exclusive spectrum rights, market activity would show evidence of a shift in usage patterns. Wireless investment would migrate to unlicensed bands. That transition has not been observed. Moreover, the competitive threat posed by unlicensed applications would devalue licenses.[27]

This view ignores the possibility of positive complementarity between the two models. Writing in 2008, with data through 2006, it might have been possible to downplay the development of hot spots and extension of broadband, which allows unlicensed use to be a complement to broadband Internet rather than a competitor. However, with the growth of offloading of traffic

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23 FCC, *Internet Access Services* and predecessor reports.
24 Thomas W. Hazlett, "Optimal Abolition of FCC Spectrum Allocation, Journal of Economic Perspectives, 22:1.
25 Hazlett, 2001.
26 Hazlett, 2008, pp. 120-121.
27 Hazlett, 2008, p. 123.

from exclusive licensed to unlicensed spectrum, the central role of unlicensed spectrum cannot be dismissed.[28]

The data in these comments and the attached paper address the analytic challenge of measuring "market activity," "investment" and the "competitive" relationship between licensed and unlicensed spectrum with the full range of data from the first decade of broadband data delivery in unlicensed spectrum. The experience of the past decade makes it clear that the questions should be framed differently because of the complementarity between licensed and unlicensed spectrum.

First, we should examine the success or failure of the unlicensed model independently of the success or failure of the exclusive licensed mode. The first question should have been

- Have advanced technologies, yielding enhanced opportunities for wireless activities to be coordinated by smart technology, strengthened the case for unlicensed use models?
- The right answer is an emphatic, ***yes.***
- In fact, there has been a shift in market usage patterns. Investment has migrated. Complementarities between unlicensed use and exclusive use have increased the value of licenses.

Examining the role of the unlicensed model in the overall success of the mobile data sector, the evidence shows that in the delivery of mobile data the unlicensed use model has achieved success that equals or exceeds the exclusive licensed model by numerous measures of economic performance, including devices, users, usage, efficiency, innovation and economic value.

Because Hazlett sets up a direct conflict between the licensed and unlicensed models in competition for future spectrum, the second question should be examined in a relative sense.

- Has the success of the unlicensed model weakened the case for licensed, if one must choose between them to make spectrum available?
- Again, the answer is another emphatic, ***yes.***

[28] Hazlett, repeated many of his argument in an August 2010, paper, that did not analyzed the evidence of the success of the unlicensed model, which had become apparent by then (Thomas W. Hazlett, *The Case for Liberal Spectrum Licenses: An Economic and Technical Analysis,* http://works.bepress.com/thomas_hazlett/1/

- With strong complementarity between the two models, it can be argued that the case for exclusive licensing has been weakened by the performance of unlicensed use in the sense that, absent unlicensed use, wireless data would be more costly and less valuable and the sector would be less efficient and innovative.

Consequently, the value of exclusive licenses would be lower without unlicensed spectrum. Faced with a flood of traffic, the operators of networks based on exclusive licenses found it cost-effective to offload huge volumes of traffic onto the unlicensed spectrum. The solution advocated by the supporters of exclusive licensing to the ongoing spectrum shortage is to make more spectrum available on an exclusive basis. From a societal view, feeding the bandwidth hogs more spectrum is less efficient than making spectrum available for both models. In fact, based on the real world experience of the performance of the two models in the past decade, a good case can be made that unlicensed use has a stronger claim to spectral efficiency than exclusive licensed use. In this sense, with respect to the allocation of spectrum between the two models, it would "reduce the case for exclusive spectrum rights." However, the policy challenge does not have to be framed in that way. The policy question is not whether to choose one model; the policy question is how to support both to continue the dramatic expansion of the wireless data sector.

III. The Demand-Side

A. Users. Uses and Usage

The dramatic success of the unlicensed model for spectrum sharing is epitomized by a series of simple observations

- In the United States, at least 80% and probably over 90% of the increase in mobile data traffic between 2010 and 2012 relied on unlicensed spectrum to provide end-user connectivity.
- The reason was that cellular providers found that offloading their broadband traffic onto unlicensed spectrum was less costly and more efficient than building more cell sites.[29]
- Yet, the greatest growth in the use of unlicensed spectrum did not come from offloading cellular traffic; it came from extending fixed, broadband service into home and office wireless networks that rely on devices equipped with protocols (e.g. Wi-Fi, Blue Tooth, etc.) that utilize unlicensed spectrum.
- Today, unlicensed spectrum carries traffic to end users that equals two-thirds of cellular licensed broadband and is expected to grow to four-fifths in the decade ahead,
- Unlicensed spectrum used to extend fixed broadband has become ubiquitous and reach one-third of fixed broadband traffic. This is expected to grow to one-half.

Both the offloading of cellular broadband traffic and the extension of fixed broadband traffic have placed unlicensed spectrum at the center of the broadband ecology (see Figure III-1). Unlicensed spectrum has become this focal point of broadband development because it is less costly to roll-out hot spots than cell sites, scales rapidly, allows users to self-provision networks, has higher throughput, uses devices that consume less battery power, and, given their origin in unlicensed space, are better equipped to handle interference, which is becoming a bigger problem as use of the spectrum increases.[30]

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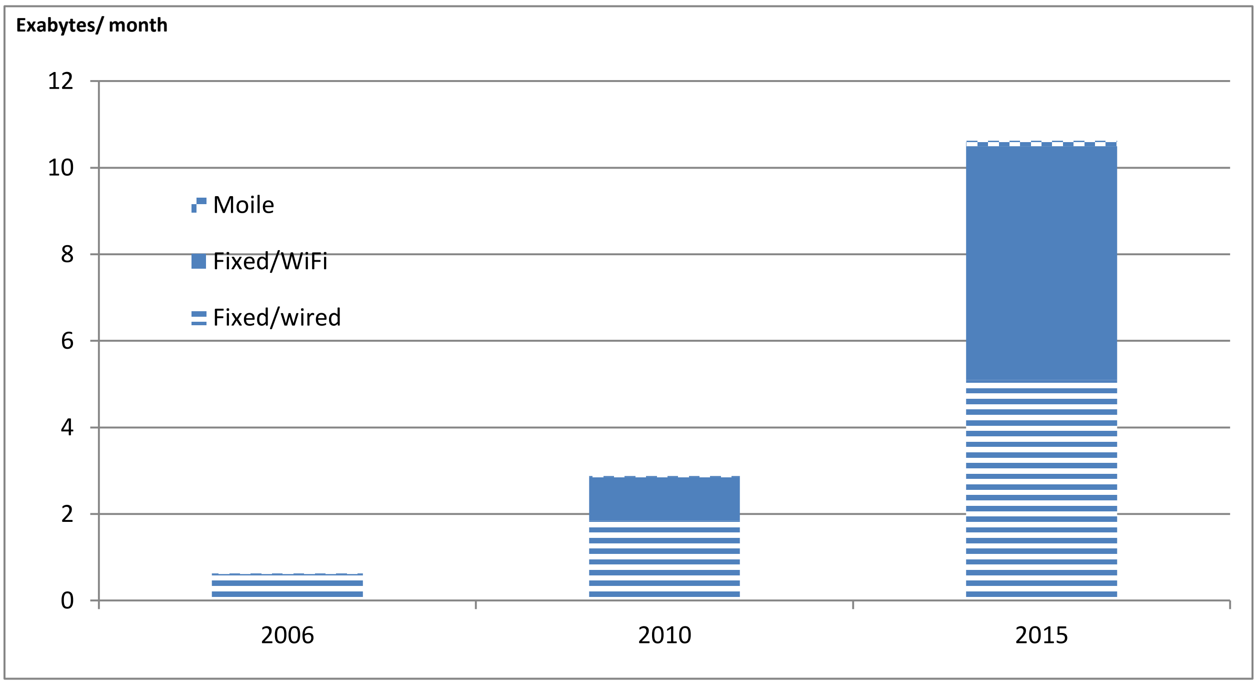
[29] Cisco IBSG, *A New Chapter for Mobile? How Wi-Fi Will Change the Mobile Industry as We Know it,"* 2011**,** Maisie Ramsay, "Wi-Fi Offloading Rising Amid Soaring Data Traffic," July 23, 2013, commenting on IGR, U.S. Wi-Fi Offload Traffic Forecast, 2011 - 2016: Relief for Mobile Data Networks? http://www.wirelessweek.com/news/2012/07/wi-fi-offload-rising-amid-soaring-data-traffic,

[30] Tom Makau, "How 3G Traffic to Wi-Fi Offloading Can Help Operators," August 14, 2012; http://tommakau.com/2012/08/14/how-3g-traffic-to-wi-fi-offloading-can-help-operators/

B. New Uses

As impressive as the past and predicted quantitative growth in traffic in the unlicensed space is, the potential for a wide range of uses that provide valuable functionalities to meet increasingly diverse demands is even more important. The combination of low cost and high functionality provided by the unlicensed model has led to a consensus among analysts that unlicensed spectrum is both a strong complement for and a potential alternative to licensed services.[31]

Figure III-1: Broadband Usage By Access Technology Across Time



Sources: *Cisco Visual Networking Index: Forecast and Methodology, 2010-2015*, June 1, 2011, for North American IP, Internet, Fixed and Mobile traffic distribution and growth rates, Cisco IBSG, *A New Chapter for Mobile? How Wi-Fi will Change the Mobile Industry as We Know it,"* 2011, for distribution and growth of Wi-Fi, Fixed and Mobile. Wikipedia for *U.S. Internet Traffic*, 2006-2011; CTIA *Semi Annual Survey,* for mobile data 2010 and earlier.

However, because mobile use is expanding so rapidly there is no reason to believe that the expansion of activity in one space will undermine or retard the expansion in the other.

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[31] Craig Moffett, Weekend Media Blast: Wither Wireless, Bernstein Research, November 18, 2011; William Gerhardt, et al., Profiting from the Rise of Wi-Fi: New, Innovative Business Model for Service Providers, Cisco Internet Business Solutions Group, March 2012; Monica Paolini, "Taking Wi-Fi Beyond Offload: Integrating Wi-Fi Access can differentiate service and generate new revenues," Open Telecom, 2012.

> The initial attitude among operators was that Wi-Fi was a temporary solution to a largely unexpected, although welcome, increase in data traffic. But it has become clear that there is room for both LTE and Wi-Fi. And operators will need both. There are many ways in which LTE and Wi-Fi will coexist, and they will lead to different strategies in monetization, service creation and customer retention.[32]

Reflecting the recognition of the broader role of unlicensed spectrum, in the past year analysis and the trade press reflect two themes – examination of the potential for direct benefits to carriers by adding service and higher projections for the value of unlicensed activity,[33] particularly associated with the "Internet of Things" (see Table III-1)). The goal is to seamlessly and securely meet an increasingly complex set of demand by selecting from available networks wherever the consumer is located in a manner that minimizes costs, provides a quality experience and increases value.

There are a number of ways that Wi-Fi can enhance the value of broadband service, some of which may be provided by cellular operators. Table III-1 reflects the focus on how network operators can monetizes these potential sources of value, but whether or not they are monetized; their existence is testimony to the enhanced value that Wi-Fi creates in the wireless space.
Table III-1 shows four functions that Wi-Fi could provide (in the four columns) to four target markets (the rows). [34] The business models or sources of value are identified in each of the cells.[35] Some of the enhancements may increase the revenues of network operators, but even if competition

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[32] Monica Paolini, "Taking Wi-Fi Beyond Offload: Integrating Wi-Fi Access can differentiate service and generate new revenues," *Open Telecom,* 2012, http://www.senzafiliconsulting.com/Resources/DownloadRequestForm/tabid/104/FileID/487/Default.aspx ;Tammy Parker, "AT&T: Wi-Fi will be in all of our small cell deployments," January 9, 2013, http://www.fiercebroadbandwireless.com/story/att-wi-fi-will-be-all-our-small-cell-deployments/2013-01-09

[33] tefficient, Wi-Fi Take 2: The Mobile Data Offload Boom: Can WiFi be Monetized this Time?, September 27, 2012; Randal Schwarz and Magus Johansson, *Carrier WiFi Offload: Building a Business Case for Carrier WiFi Offload,* March @012.

[34] Monica Paolini, "Taking Wi-Fi Beyond Offload: Integrating Wi-Fi Access can differentiate service and generate new revenues," *Open Telecom,* 2012, for the network targets and sources of enhance value. End-to-End policy-based security, which is noted by Paolini appears to be a requisite for all of the enhanced values to be created.

[35] William Gerhardt, et al., Profiting from the Rise of Wi-Fi: New, Innovative Business Model for Service Providers, Cisco Internet Business Solutions Group, March 2012.

drives the functionalities and services into the cellular broadband bundle without a charge, consumers will still enjoy their value. Given these potentially valuable services, we would expect the role of Wi-Fi to expand in the wireless data space.

TABLE III-1: NEW AND INNOVATIVE MODELS FOR TAKING WI-FI BEYOND OFFLOAD

Targeted Market	Sources of Enhanced Value			
	PERSONALIZED, FLEXIBLE ACCESS	VENUE-BASED ANALYTICS	OPTIMIZED RESOURCE ALLOCATION	ROAMING
PRIVATE WI-FI ACCESS				
Home	Connectivity: Direct, Premium Video		Alternative connectivity	
Enterprise	Business, M-2-M Connectivity, Extended CDN			Business anywhere
PUBLIC WI-FI ACCESS Free & Partner Hotspot		Advertising, Targeted Marketing	Hosted small cells Subletting	
Operator Network	Embedded connectivity		Offloading, Reduced churn	Seamless roaming

Sources: * William Gerhardt, et al., *Profiting from the Rise of Wi-Fi: New, Innovative Business Model for Service Providers,* Cisco Internet Business Solutions Group, March 2012, ** Monica Paolini, "Taking Wi-Fi Beyond Offload: Integrating Wi-Fi Access can differentiate service and generate new revenues," *Open Telecom,* 2012.

Many of these services appear to involve a potential evolution toward and growing importance of a new type of service that has been called "nomadic." In short order, nomadic applications may come to dominate a world that had heretofore been split between fixed and mobile. The dichotomy between "mobile" and "fixed" is being eroded. Truly mobile uses in which the transmission of data is handed off from one cell site to another has always been a small fraction of use. The vast majority of traffic even on cellular networks was delivered to people who are stationary.[36] They move from one site to another, but then remain in one place while the use the

[36] Matias Toril, et al., "Analysis of User Mobility Statistics for Cellular Network Restructuring, IEEE, 2009; Cisco, *What Do customers Want from Wi-Fi?,* June 2012; Center for Strategic and Economic Research,

network. As hotspots expand into hot zones (particularly with access to spectrum with better propagation characteristics) and integrate into seamlessly, nomadic networks emerge and more traffic can be delivered as fixed Wi-Fi. [37]

C. THE INTERNET OF THINGS AND THE GROWING DIVERSITY OF COMMUNICATIONS NEEDS

Included in the array of potential new services and functionalities in Table III-1 above are categories of activities that make up the Internet of Things, which is widely seen as the most dramatic area of growth in the wireless space over the next decade, one which will see tens of billions of devices interconnected wirelessly. [38]

> The Internet and wireless communications services have grown in recent decades into mass market infrastructure. Their on-going convergence holds the promise of a pervasive communications fabric that is always and everywhere accessible for everyone and everything that wants to communicate. With such a capability comes the prospect of widespread automation and real-time control of real-world systems, or equivalently, the cyber-real world convergence.[39]

Diversity of services and traffic characteristics is both an opportunity and a challenge. The challenge of delivering wireless data as usage expands will be made more complex by the fact that different types of communications place different demands on the network. Variety creates complexity. However, it may also alleviate some of the traffic flow problems because different types of communications place less demand on the network and can be served by the networks that constitute the wireless space.

Key conditions that vary across applications identified in the literature involve latency, connectivity, coverage and bandwidth at affordable costs, as shown Figure III-2. As shown in the

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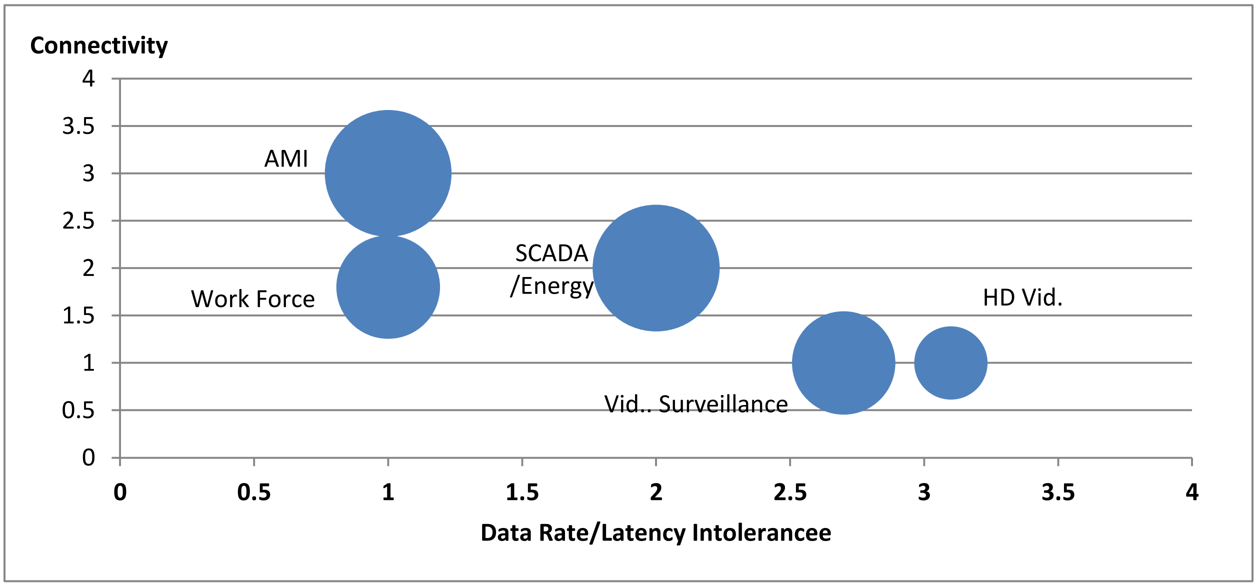
California Mobile Usage Overview, January 24, 2012; Joohyun Lee, et al., "economic of WiFi Offloading: Trading Delay for Cellular Capacity, December 31, 2012.

[37] Yochai Benkler, Unlicensed Wireless vs. Licensed Spectrum: Evidence from Market Adoption, 2011; John M. Chapin and William H. Lehr, "SCADA for the Rest of Us: Unlicensed Bands Supporting Long-Range Communications," *38th Research Conference on Communications, Information and Internet Policy*, 2010

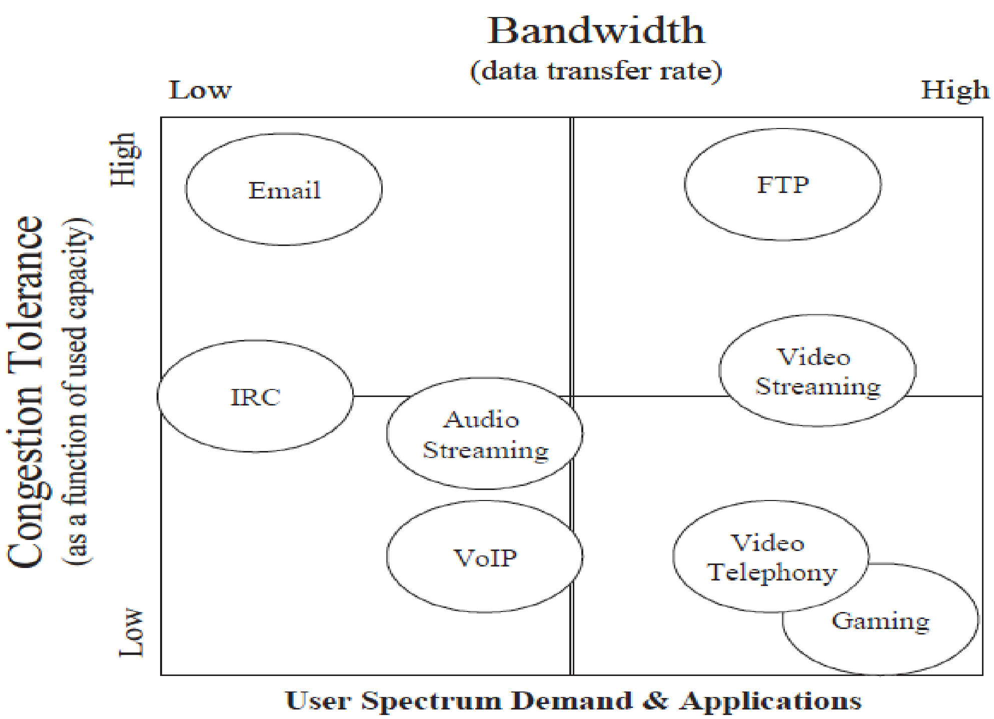
[38] Benkler, 2011, Richard Thanki, The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum, Perspective, 2009; Steve Lohr, "The Internet Gets Physical," New York Time, December 17, 2011

[39] Chapin and Lehr, 2010, p.1.

FIGURE III-2: DIVERSITY IN SERVICE NEEDS
(size of circles measures sensitivity to device costs)



Sources: Guzelgoz, et al. emphasize Data Rate/Latency – i.e. low data rate, high tolerance for latency; Chapin and Lehr, 2011, emphasize cost i.e. need for low cost; Benkler, 2011, emphasizes connectivity, i.e. need for Connectivity;



Source: Mark M. Bykowsky, Kenneth Carter, Mark A. Olson and William w. Sharkey, *Enhancing Spectrum's Value Through Market-Informed Congestion Etiquettes,* February 2008.

Enhancing Coverage

top graph, using a simple three point scale (low, medium, high) for three communications characteristics for five broad types of intermediate input services suggests the complexity of the emerging communications space. For example, at one extreme, advanced metering tolerates a low data rate/hi-latency, needs low cost radio technology, and does not need a high level of connectivity. Video applications have the opposite set of requirements. Affordability is defined by the interaction of the cost and value.

The bottom graph reproduces a two dimensional analysis of mass market applications that yields a similar view of the terrain of demand. The bottom graph focuses on mass market applications according to bandwidth needs and congestion tolerance. E-mail and gaming are polar opposites in this categorization.

In order to meet the diverse needs, the complementarity between licensed and unlicensed spectrum will have to continue and grow,[40] particularly with respect to the problem of geographic coverage[41] by evolving new institutions to deal with interference. In order to achieve this increasingly complex complementarity and maintain the balance between the approaches, making spectrum with different propagation characteristics available to both models is important.

Figure III-3 conceptualizes the geographic space of the wireless future. It suggests how access to spectrum in the 500 MHz to 1 GHz range could dramatically improve the performance

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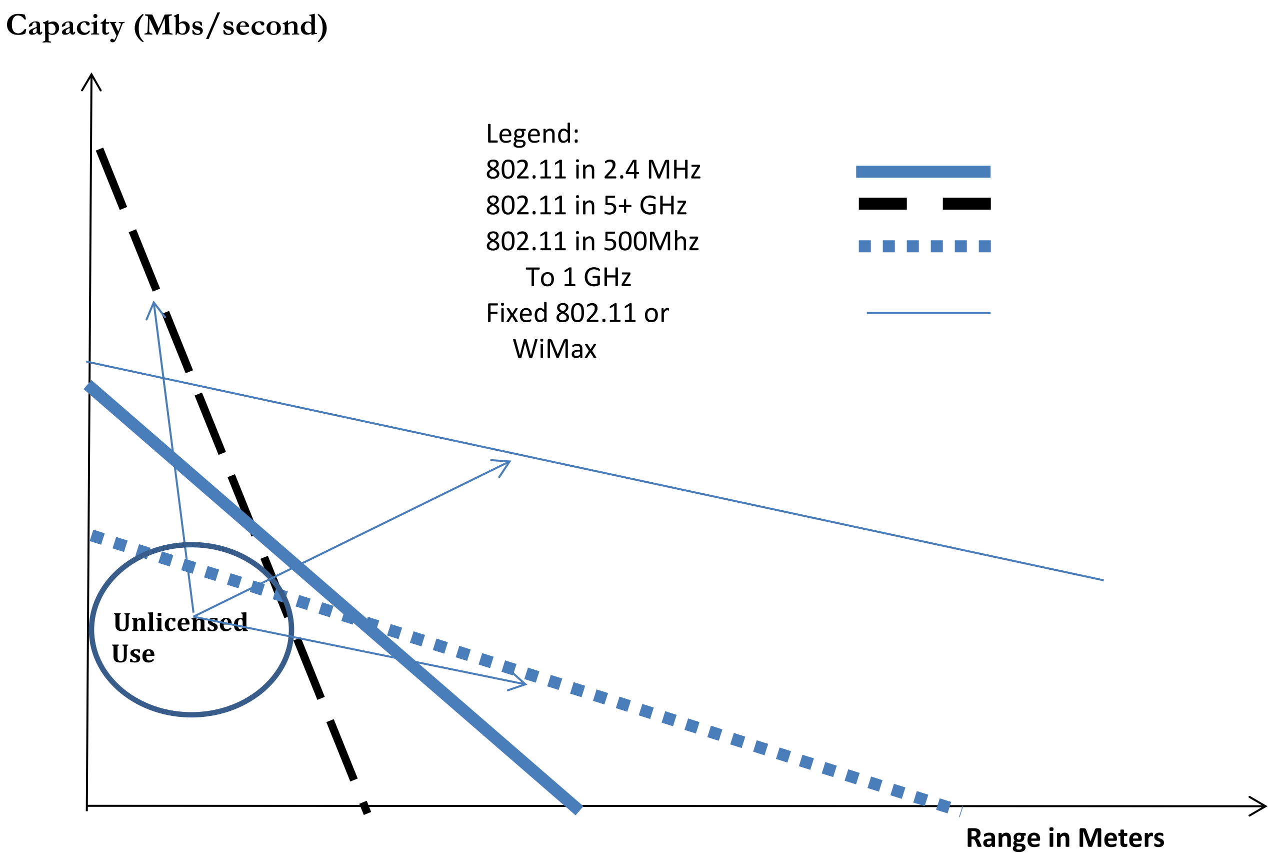
[40] Chapin and Lehr, 2011, p. 32, "A key driver of the need for increased sharing among CMRS operators is the need to shrink cell sizes. Smaller cell sizes enable efficient spatial reuse of spectrum and support lower power operations, as well as a number of other technical options such as network MIMO. Lower power operation has many benefits, including ameliorating concerns about any potential health risks. Moreover, lower power operation facilitates the sharing of spectrum. There are multiple reasons for this, including the fact that it provides better range matching between licensed and unlicensed spectrum and the technology for frequency agility is more advanced and affordable."

[41] Chapin and Lehr, 2011, p. 21, "The move to smaller cell sizes that is driven, in part, by spectrum scarcity, makes infrastructure sharing between dedicated and unlicensed (range restricted) spectrum easier. It is important to note that cell density does not need to increase to the point that unlicensed bands can be used to reach any mobile device. Unlicensed spectrum can be used for mobile devices that are close to the infrastructure antenna, with dedicated CMRS spectrum used to reach mobile devices that are further from the antenna. The cell density merely needs to be reduced to the point that a substantial fraction of mobile users are within range of the unlicensed band from an infrastructure antenna, in order to provide significant offload."

and expand the scope of the unlicensed use model. Holding power constant and allowing Wi-Fi technology to operate at different frequencies affords it better coverage, or higher capacity. The

FIGURE III-3: THE POTENTIAL COVERAGE AND CAPACITY GAINS FROM ACCESS TO HIGHER QUALITY SPECTRUM



Sources:

These estimates are a representation of the general gain in capacity and reach based on Richard Thanki, *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum,* Perspective, 2009 and Dirk Grunwald, *How New Technologies Can Turn a Spectrum Crisis Into a Spectrum Opportunity,* February 2011. The precise degree to which the range and capacity are increased depends on the amount of spectrum made available and the rules of use.

bulk of end-user activity at present takes place in the 2.4 GHz spectrum and affords it a limited coverage. Use of 5 GHz (and perhaps higher) bands will allow higher capacity that can support new applications or improve the performance of existing applications, but it does not solve the problem of the limited range imposed on the unlicensed use model by its exclusion from higher quality spectrum. Using the TV white spaces[42] example, access to higher quality spectrum[43] would more than double the coverage.[44] Hot spots could become "Hot Zones or Oases."[45] In areas where the current exclusive licensed frequencies are unused; it would be possible to use more power to increase the capacity and coverage of Wi-Fi in fixed applications. WiMax would operate in this space as well, but it requires greater control of interference, which has given rise to a hybrid, lightly licensed model.[46] Here lies a solution to the universal service problem of high cost first mile broadband.

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[42] Lauri Lamberth, 2011, "White Space and the Internet of Things," *MSolve Partners Newsletter,* September 2011, In the United States and U.K. TV white spaces occupy positions low on the frequency map meaning that the signals penetrate building better, travel farther and cover larger areas than higher-frequency signals. TV white space transmissions can carry as far as 10km/6.2 miles, which is more than 100 times better than Wi-Fi operating range of 100 feet indoors and 300 feet outdoors. Data throughput rates are in TV white space spectrum are high… Because of these attributes, the U.S. Congress and FCC call TV white spaces "Wi-Fi on steroids" and "super Wi-Fi" (even though white space devices do not conform to IEEEs 802.11 Wi-Fi standard)…. One of the thorniest problems is that white spaces aren't available in the same amount or on the same channels everywhere… Because white space availability is generally better in rural areas, the first white space solutions are to be offered for sale may be skewed toward solutions that benefit these communities, such as pubic broadband services. "

[43] Lamberth, 2011, "TV white spaces are available to anyone on an unlicensed basis, similar to Wi-Fi. That means any device can use the spectrum so long as it complies with a set of rules that prevent it from interfering with licensed users, wireless microphones and other white space devices. These rules present some fairly steep technology requirements: white space devise must function at restricted power levels, use adaptive power control to ensure they are radiating at the lowest level possible, know where they are, and connect to the Internet in order to access a geotagged spectrum availability database. In both the United States and U.K., proposed requirements that would require white space devices to sense and avoid other signals on the channels they're using were dropped based on technological feasibility, timing and cost, though both regulators would prefer this approach should it become feasible in the future. "

[44] Thanki, 2009, also presents a calculation of the difference that having access to high-quality spectrum would make in increasing the coverage of 802.11g devices. At the power level allowed by the sharing rules, the coverage is tripled by having access to higher quality spectrum. Coverage is much greater in rural areas because of fewer obstacles, but even in urban areas the difference is considerable. Given the high cost of providing rural areas with broadband Internet access, making this spectrum available for shared use would be particularly important in these areas.

[45] Benkler, 2011.

[46] The distinction between unlicensed with stronger rules for preventing interference and lightly –licensed blurs as they meet. Wikipedia defines lightly licensed as follows: "In June 2007 the FCC issued final rules for a novel "light licensing" scheme in the 3650-3700 MHz band. Licensees pay a small fee for a nationwide, non-exclusive license. They then pay an additional nominal fee for each high powered base station that they deploy. Neither the client devices (which may be fixed or mobile), nor their operators require a license, but these devices must receive an enabling signal from a licensed base station before transmitting. All stations must be identifiable in the event they cause interference to incumbent operators in the band. Further, there is a requirement that multiple licensees' devices are given the opportunity to transmit in the same area using a "contention based protocol" when possible. If interference between

As coverage expands, interference management becomes more challenging. The solution lies at the institutional level. Expanding range requires additional measures to prevent interference, which can be provided in a number of ways including a mix of known technology and policy,[47] and the innovation that can be expected once the barrier to wider coverage is removed.

A detailed analysis of the diverse characteristics is not critical to the task of evaluating the future contribution of unlicensed use. The discussions recognize the complexity of the communications ecology that is emerging and that unlicensed use is likely to have a significant role in the future because it is better suited to provide important functionalities to support several of the configurations of demand characteristics. As long as spectrum policy does not bias the outcome by favoring one approach at the expense of the other, both would expand to meet growing demand. Moreover, by offering both models the opportunity to expand the amount of activity is likely to be higher and efficiency greater.

The past success of the wireless data sector is remarkable and the potential future benefits are great, but the challenges are great too. The irony is that the wireless sector has been so successful over the past decade that the debate has shifted 180 degrees. It started from a situation in which analysts had to fight to convince policymakers that an immense amount of value was being

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licensees, or the devices that they have enabled, cannot be mediated by technical means, licensees are required to resolve the dispute between themselves." http://en.wikipedia.org/wiki/IEEE_802.11y-2008.

[47] Chapin and Lehr, 2011, p. 7, "Below a threshold cell size, network MIMO techniques become feasible.a/ a/ Most users are familiar with the new class of WiFi routers that use 802.11n MIMO (Multiple Input-Multiple Output) technology. This is implemented on each wireless router by using three antennas to take advantage of multipath to disentangle the desired signal from noise, and thus improve system performance. Similar strategies can be employed by integrating the signals from multiple networked base stations to enable network MIMO, if cell size is small enough that mobiles are in range of multiple base stations at the same time. In addition to expanding capacity, network MIMO provides benefits to reliability (because of path diversity and redundancy), coverage (dead-spot elimination), and data rate. p. 17, "By the term *controlled access unlicensed band* we refer to the general class of unlicensed allocations made in recent years." In the "original" unlicensed bands… an unlicensed device can transmit at any time as long as no interference occurs to protected users…. More recent unlicensed bands preserve the property that any device can use the band without exclusive licenses, but they have placed increasingly strict requirements on unlicensed transmitters. These requirements have been necessary to protect incumbents from interference since the new unlicensed allocations have been carved out of partially used spectrum bands."

wasted in spectrum that was locked into static broadcast applications; but we now have arrived at a situation in which there is so much potential use and value that we face a perpetual "spectrum crunch." Traffic growth has been so great and is likely to remain so rapid that there inevitably will be a series of "spectrum crunches," even if more bands are made available to exclusive licenses.[48]

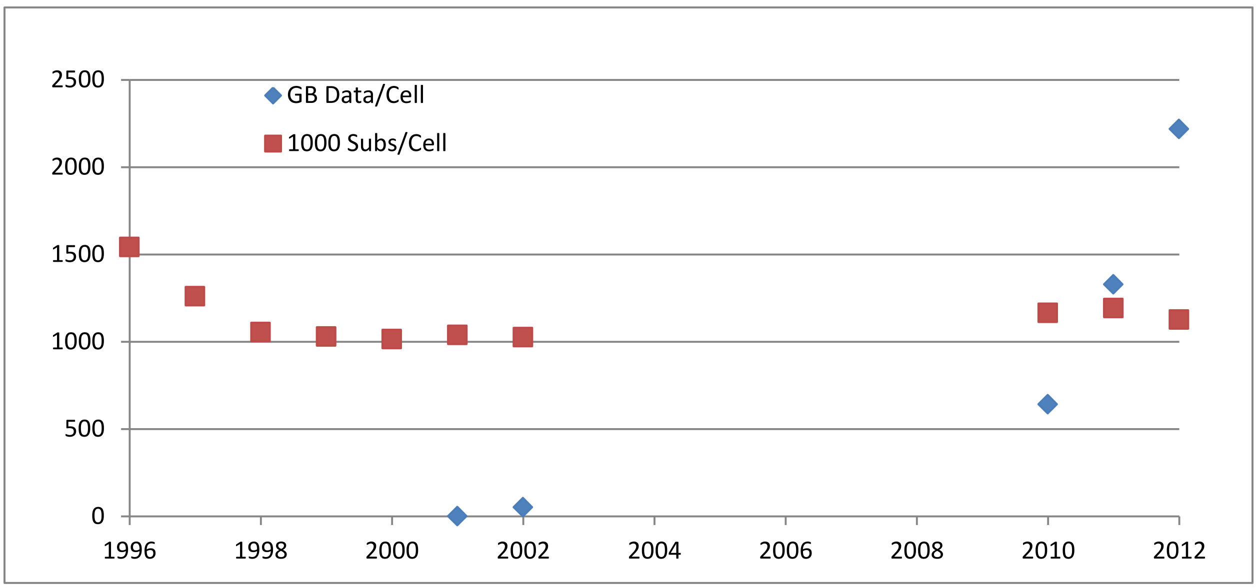
[48] Dan McBride, "Technologies and Strategies for the Mobile Broadband Capacity Crunch," May 13, 2011, "Technologies and Strategies for the Mobile Broadband Capacity Crunch," (May 13, 2011), Traffic growth is just too great. Spectrum capacity will run out (and/or services will suffer), costs of continual expansion of core network and backhaul capacity will undermine operator profitability. Operators are all juggling with the need to divert non-essential traffic off of their networks in order to protect the performance and throughput of these vital assets. Offload is seen as the answer… the immediate future… of identifying and selecting specific types of traffic, content and even devices, creating new paths – outside the operator networks core – for access to and delivery of content. Further down the road, it is all but inevitable that the mobile data network will become a fully distributed environment that behaves like the Internet today, with no central core."

IV. The Supply-side

A. Efficiency in Infrastructure Deployment

The supply-side value of unlicensed spectrum comes primarily from the fact that it enables cellular operators to deliver traffic with fewer cell sites. It is far less costly to use the ubiquitous unlicensed spectrum and the chips sets that are widely deployed in devices than deploy more network equipment to shrink the size of cells. In our 2011 report we estimated 130,000 cell sites based on provisioning of suburban cells. That estimate of the supply-side value of Wi-Fi to the mobile data economy seems reasonable and may be low.

Figure IV-1: Mobile Broadband Data Traffic and Cell Sites



Source: CTIA *Semi Annual Survey*.

Figure IV-1 shows the number of subscribers per cell site and the amount of broadband data traffic per cell site. We observe that the traffic flow has more than tripled since the advent of offloading. If the cellular carriers had delivered that traffic by using the spectrum for which they held licenses, they could claim a remarkable technological and economic accomplishment. That would have required the building of hundreds of thousands of cell sites (essentially to shrink the number of subscribers per cell). They did not choose, or were unable to do so.

Offloading traffic into unlicensed spectrum was seen as a less costly and more efficient alternative. If the licensed cellular operators had found it necessary to maintain the ratio of cell sites to date usage that obtained in late 2009 (prior to the advent of massive Wi-Fi offloading), they would have had to add over 160,000 cells sites. With the volume and diversity of traffic projected to increase dramatically in the decade ahead, the role of unlicensed spectrum will increase.

B. INNOVATION

Our 2011analysis showed that innovation in the Wi-Fi space was at least equal to, and probably much greater and faster than, innovation in the cellular licensed space. The evidence to support that conclusion about the performance of the two models over the long-term is repeated in Table IV-1. We can add several of observations to this long-term analysis.

While the cellular carriers plod along rolling out their 4G networks to boost the efficiency of use of the licensed spectrum, unlicensed space is experiencing a continuous flow of innovation that makes unlicensed spectrum more valuable and functional. For example, the services and functionalities identified in Table III-1 rely new specifications[49] that flow from the process that is at the heart of the unlicensed model – "co-invention, the complementary invention that makes advances in general purpose technology valuable in particular places at particular points in time."[50]

The weakness of the cellular licensed model in delivering innovation that is responsive to the emerging environment can be seen in the failure to develop cellular receivers that can cope with the increasingly noisy environment of the broadband era. This weakness has led to calls for regulators to step in, where entrepreneurs have failed, to mandate more receiver capability.[51] The resource

[49] Hotspot 2.0, Next Generation Hotspot, Access Network Discovery and Selection Function, Paolini, 2012, p.4.

[50] Shane Greenstein, Building and Delivering the Virtual World: Commercializing Service for Internet Access, March 31, 2000, p. 2

[51] J. Pierre de Vries, *Optimizing Receiver Performance Using Interference Limits,* Telecommunications Policy Research Conference, 2012

TABLE IV-1: INNOVATION IN UNLICENSED USE AND EXCLUSIVE LICENSED USE SPECTRUM

	EXCLUSIVE LICENSED USE	UNLICENSED USE
Standards Released		
	2G – GSM 1993	IEEE 802.11-1997: WLAN standard originally 1 Mbit/s and 2 Mbit/s,
	2.75G- GSM+EDGE	IEEE 802.11a: 54 Mbit/s, 5 GHz standard (1999
	3G – CDMA 2000	IEEE 802.11b: Enhancements to 802.11 to support 5.5 and 11 Mbit/s (1999)
	3G – 1x EV-DO Rev A	IEEE 802.11c: Bridge operation procedures; included in the IEEE 802.1D (2001)
	3G- WCDMA	IEEE 802.11d: International (country-to-country) roaming extensions (2001)
	3.5g – HSPDA	IEEE 802.11e: Enhancements: QOS, including packet bursting (2005)
	WiMAX – IEEE 802.16	IEEE 802.11g: 54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)
	4G – LTE	IEEE 8702.11h Spectrum Managed 802.11a (5 GHz), European compatibility (2004)
		IEEE 802.11i: Enhanced security (2004)
		IEEE 802.11j: Extensions for Japan (2004)
		IEEE 802.11k: Radio resource measurement enhancements (2008)
		IEEE 802.11n: Higher throughput improvements using MIMO
		IEEE 802.11r: Fast BSS transition (FT) (2008)
		IEEE 802.11w: Protected Management Frames (September 2009)
		IEEE 802.11y: 3650–3700 MHz Operation in the U.S. (2008)
Network Technologies		
Digital Spread Encoding	1991	1988
Spread Spectrum	1995	1988
OFDM	2006	2001
MIMO/Adaptive Beamforming	2008	2004
Applications:		
Radical	Precise global positioning	Precise urban positioning, Real-time location
	Wide area networks	Local area networks/wireless broadband
	Satellite based	Novel wireless connectivity (critical device monitoring, monitoring and control in adverse environments)
	Communications	Automatic building control, Wireless sensor networks
Incremental	Mobile TV	Personal area networks/Cable replacement (computer mice, keyboards, printers, head sets, headphones
	Services, texting, picture, messaging,	Contactless payment
	video calling, secure mail	Supply chain improvement
	Data over broadcast	Consumer electronics (Wi-Fi radio, STBs
	Networks (subtitling & video text)	Identification (RFID - Humans, Animals, Goods), Remote controls

Major Handsets Launched

6/29/07 AT&T Apple iPhone
11/19/07 VZW LG Voyager
4/1/08 Sprint SamsungInstinct
7/10/08 Apple iPhone 3G
7/11/08 AT&T HSDPA iPhone 3G
9/23/08 T-Mobile Android G1
10/21/08 AT&T Samsung Epix
11/4/08 AT&T Blackberry Bold
11/20/08 Sprint HTC Touch Diamond
11/21/08 VZW Blackberry Storm
2/24/09 AT&T Matrix Pro
2/26/09 VZW LG Versa
3/2/09 Sprint Palm Pre
4/1/09 MetroPCS Samsung Finesse
7/13/09 VZW & Sprint Blackberry Tour
9/21/09 Cellular South HTC Hero (Android)
EOY 2009 LG Watch Phone

A Few Examples of Certified Wi-Fi-Enabled Devices

Networking Equipment - Access Point/Router
Access Point for Home or Small Office (Wireless Router) Enterprise Access Point, Switch/Controller or Router Mobile AP
Networking Equipment - Gateway
Cable, DSL or Other Broadband Gateway (Integrated Home Access Device)
Consumer Electronics - Cameras
Digital Still, Portable Video, Networked Web
Consumer Electronics - Audio Devices
Digital Audio - Stationary (speakers, receiver, MP3 player)
Digital Audio - Portable (MP3 player)
Consumer Electronics - Video Devices
Set Top Box, Media Extender, Media Server
Display Device (eg. television, monitor, picture frame)
Consumer Electronics - Gaming Devices
Game Console or Game Console Adapter
Gaming Device - Portable
Consumer Electronics - Storage and Servers
Media Server or Media Adapter
Network Storage Device (networked hard drive)
PCs and Computing Devices - Adapter Cards
External, Internal Wi-Fi Adapter Card
PCs and Computing Devices - Computers and PDAs
Laptop Computer, Ultra-mobile PC, PDA
PCs and Computing Devices - Printers
Printer or Print Server (includes scanner and fax)
Voice-Capable Devices - Phones
Phone, dual-mode (Wi-Fi and cellular)
Phone, single-mode (Wi-Fi only)
Smartphone, dual-mode (Wi-Fi and cellular)
Smartphone, single-mode (Wi-Fi only)
Other
Barcode Scanner

Sources:
Gerald R. Faulhaber and David J. Farber, *Innovation in the Wireless Ecosystem: A Customer-Centric Framework* (2009) for exclusive license standards major handset launches; Wi-Fi Alliance, Wi-Fi Certified Products, http://www.wi-fi.org/certified_products.php for Wi-Fi-enabled devices; Richard Thanki, *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum,* Perspective, 2009, pp. 37-39).

management architecture of the cellular networks may also result in "wasting scarce radio resources and handset energy."[52]

Thus, the spectrum crunch that has motivated the auction frenzy is, to a significant extent, the result of two weaknesses in the cellular licensed model – the failure to deploy network infrastructure, optimize utilization of network resources and advance end-user devices. Ultimately, the superior economics and institutional structure of the unlicensed model dictated a large and growing role for unlicensed applications. The key challenge for policy makers is to ensure that in the stampede to alleviate the weaknesses of the cellular licensed model, the immense potential of the unlicensed model is not trampled.

C. Competition

The primary force underlying the superior performance of (and one of the primary benefits from) the unlicensed model is to stimulate entry into a space that has been become highly concentrated. As shown in Figure IV-2, concentration takes an inevitable toll on market performance. The dramatic increase in concentration in the past decade is correlated with stagnation in price declines and the failure to deploy infrastructure.

This process of concentration and subsequent poor performance in the cellular space might reflect inherent economies of scale and scope in the cellular licensed market that will not support sufficient competition to promote better performance. It could reflect the failure of antitrust and public policy to ensure the maximum amount of competition possible. In either case, the unlicensed model is much more attractive. Either way, expanding the role of unlicensed is an attractive and proven way to deconcentrate the wireless space.

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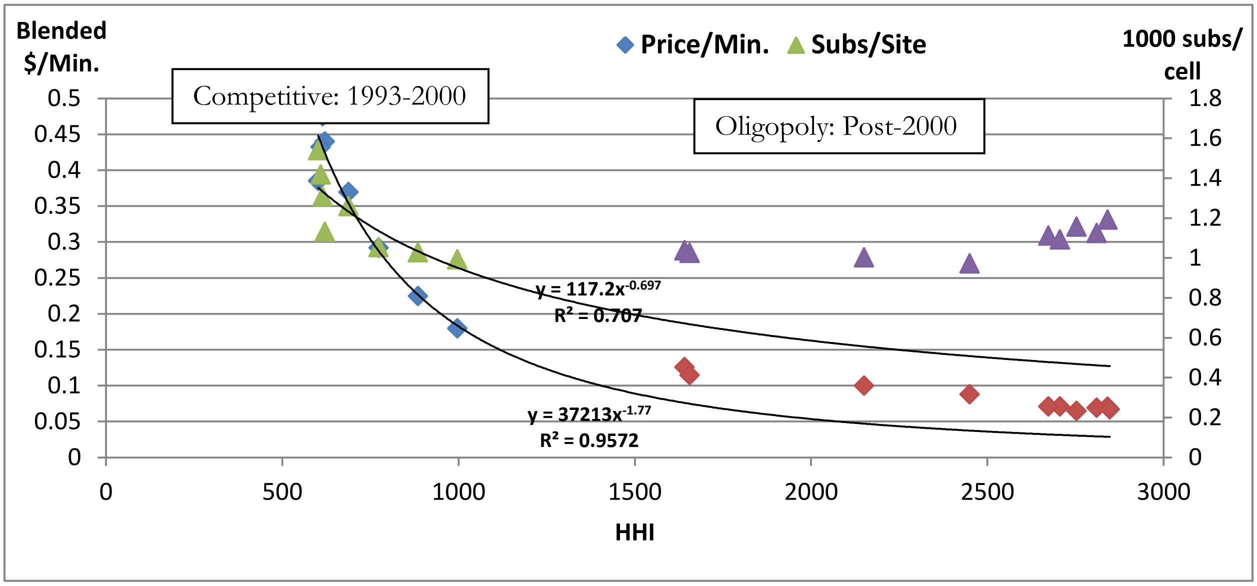
[52] Feng Qian, et al., "Periodic Transfers in Mobile Applications: Network-wide Origin, Impact and Optimization, April 2012, *International World Wide Web Conference Committee,* Lyon France, Feng Qian, et al, "Profiling Resource Usage for Mobile Applications: A Cross-Layer Approach," *Mobisys'11,ACM,* July 2011 ; Ville Kononen and Pekka Paakkonen, "Optimizing Power Consumption of Always-On Applications Based on a Timer alignment, *IEEE* 2011;

FIGURE IV-2: CONCENTRATION OF THE CELLULAR MARKET AND MARKET PERFORMANCE – PRICE AND CELL SITE DEPLOYMENT



Sources: HHI: FCC, *Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services.* Concentration before 2003 is from Eli Noam, *Media Ownership and Concentration in America* (Oxford, New York, 2009); cell sites, subs and price per blended minute, CTIA *Semi Annual Survey.*

Moreover, to the extent that reform and repacking of spectrum utilization makes a significant amount of spectrum available for auction, the availability of a significant amount of high quality spectrum available should be seen as an opportunity to deconcentrate the cellular space. . With data traffic expected to grow dramatically in quantity and diversity, this is a key moment where additional spectrum available to the smaller cellular carriers could enable them to reach the scale necessary to be viable and compete with the dominant incumbents. After taking the needs of unlicensed into account, the auction should be viewed as an opportunity to deconcentrate the cellular wireless market

Complementarity and Rivalry Between Spectrum Use Models Enrich the Wireless Space

The expansion and nimble integration of unlicensed use technologies with the exclusive licensed model has played a key role in the development of broadband data service. It is likely to continue to play a vital part in promoting an efficient solution to the long-run challenge of provisioning mobile data services.[53] Unlicensed use of frequencies is one of the key technologies that provide a platform that makes possible much more intensive use of spectrum. [54]

The two ownership models can expand to deliver these functionalities along two dimensions – geographic and organizational. While convergence is frequently used to describe this process, convergence has taken on a connation that implies networks inevitably compete and replace one another, but the relationship between licensed and unlicensed use of spectrum entails a great deal of complementarity, co-existence. Complementarity and functional specialization are likely to continue to be central features of the wireless broadband ecology, although competition may increase as well. Networks based primarily on exclusive licenses will continue to perform better by integrating unlicensed spectrum,[55] but services that rely primarily on unlicensed may expand as well.

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[53] Wirelesse2e, 2011, "Cost of Adding Network Capacity: More Spectrum or New Sites? Could there be Other Alternatives, "May 17, "In summary, choice for the wireless network executive is not a simple bifurcation between spectrum and additional cell-sites." Instead a multi-pronged approach is the advisable path: Deploy the technology advances (spectrum efficiency), Make spectrum purchases to plan for traditional macro, micro cell deployments for dense urban, urban and rural coverage, Identify hotspots (those 3-4% of sites that will carry 30-40% of total network traffic) and find ways to use dense Wi-Fi deployments to off-load traffic, Work with device manufacturers to promote the adoption of higher orders of MIMO for 802.11n and the use of 5 GHz band."

[54] Rysavy Research, Strategic Use of Wi-Fi in Mobile Broadband Networks, October 14, 2010, p. 10. Wi-Fi is becoming increasingly more effective as a broadband access solution for the following reasons: The IEEE 802.11n provides for extremely high throughputs (maximum 6000 Mbps theoretical rate), high spectral efficiency, extended range, multi-band support, and operating flexibility in trading off between distance and throughput. Wi-Fi can be deployed at lower cost than most alternative technologies, especially in environments where little wireline infrastructure exists. Time to market is also faster. Maturing operator-class Wi-Fi equipment has the sophisticated functionality needed to work in these challenging RF environments… New equipment enables flexible deployment. Examples include mesh operation and Wi-Fi based point-to-point communications for backhaul; Phil Marshall, "Mobile Broadband Network Design Key to Profit?" *Enriching Communications,* April 11, 2011. Unlike traditional services where dedicated connections are provisioned, broadband services can leverage unlicensed connections that are 'virtualized' according to principles developed for Internet- and Web-based network technologies. Tremendous performance gains and capital efficiencies can be achieved with intelligent scheduling and bandwidth management techniques…Notable innovations are particularly focused toward enabling low cost platforms for small cells, software defined radio configurations, and automated configuration and provisioning management. Many of these innovations capitalize on technical capabilities derived from the Internet.

[55] John M. Chapin and William H. Lehr, "Mobile Broadband Growth, Spectrum Scarcity, and Sustainable Competition," 39th Research Conference on Communications, Information and Internet Policy 011, p.28,"operators who segregate their traffic may be better positioned to take advantage of dedicated unlicensed spectrum to supplement their overall capacity needs. "

While we have seen and expect future complementarity and functional specialization, we should not dismiss the possibility of rivalry as well. At a minimum, exactly where the line between the services will be drawn is an open question that should be decided in the marketplace, not determined by policies that decide the outcome by allocating spectrum to one model and not another.

A leading Wall Street analyst of the communications space has recently described two possibilities that are emerging in the marketplace that rely on the ubiquity of unlicensed spectrum-based Wi-Fi. [56] For cable operators it provides for the continuing extension of broadband as the driving force behind the adoption. There is also the potential for a full purpose wireless service to develop that relies primarily on Wi-Fi as larger, more dense hot spots could grow into a nomadic network of hot zones that meet consumer needs network with wider coverage. [57]

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[56] Moffett, 2009, p. 3, "If there is an opening for cable operators in the wireless industry, it is far more likely to be in offering Wi-Fi than in offering LTE… Their strategy is to give away Wi-Fi service for free. They've made wireless a feature. The strategy actually makes sense. They rely on free spectrum and low cost Wi-Fi equipment. They leave it to consumers to foot the bill for equipment (i.e. The Wi-Fi chips that are already build into iPhones and iPods and laptops), meaning there's little or no subscribe acquisition costs." Earlier this week, we wrote about even more disruptive opportunity made possible by Wi-Fi. A start-up named Republic Wireless is now beta testing an unbelievable $19 per month unlimited plan for voice, video and data. The plan is made possible by the emerging ubiquitous availability of Wi-Fi. Republic's modified LG OPimus Android smartphone defaults to Wi-Fi… even for voice service. Importantly, the service does include full ("unlimited") cellular capability whenever Wi-Fi isn't available (via an MVNO arrangement with Sprint). That positions Republic as a credible replacement for higher priced plans (including, those, ironically, from Sprint). This kind of service would be a natural fit for cable. Inside the home, it would leverage the customer's own Wi-Fi network (that is, their cable broadband connection). At work, it would leverage their employer's network. At malls and restaurants and city centers, it would leverage the Wi-Fi network increasingly being built by Comcast, Time Warner Cable and Cablevision. The customer would only need a traditional cellular network in a car."

[57] Benkler, 2011, pp. 19-20, [I]f Congress does empower the FCC to move broadcasters so as to make it easier to deploy new uses of wireless technologies, it becomes possible to use that change to permit open wireless devices to transmit in some of the cleared frequencies, rather than auction all of the cleared frequencies for exclusive use. A dedicated band in which only open wireless devices would operate, rather than on a shared basis as with white spaces, would allow the development of devices with longer range and higher power. These would be constrained not by the sensitivity of older, less sophisticated services like broadcast, but only by what new devices specifically built for open wireless use can bear. The primary potential benefit of such new devices would be increased area coverage, particularly in built environments. By increasing coverage, these devices could make the kinds of nomadic access we already see from open wireless strategies more seamless. In other words, a dedicated band in these lower frequencies could provide precisely the capabilities that could fill in the primary weakness that current open wireless

V. ECONOMIC VALUES

A. ESTIMATES OF THE VALUE OF ECONOMIC ACTIVITY IN THE UNLICENSED SPACE

In our earlier analysis we estimated the demand side value of economic activity in the unlicensed space by identifying the prices charged for standalone Wi-Fi services or their equivalents in the market. We put the figure at $36 billion. We estimated the supply-side value of use of unlicensed spectrum by directly estimating the avoided cost of building towers combined with estimates of the productivity gains from by business from the intensive use of communications and the Internet of things. The supply-side value was placed at $34 billion. Given the much higher levels of activity documented above, those estimates are likely to be too low, as suggest by Exhibit V-1.

Several aggregate estimates put forward are substantially higher. Moreover, the estimates provided by Cisco suggest that the value individual services suggest the value would be very large. With the number of users approaching 100 million in the U.S. alone and usage approaching a trillion gigabytes per month, these services would reach hundreds of billions if these services are valued as estimated by Cisco. This is consistent with aggregate estimates of the Internet of Things alone.

An aggregate view of the value of wireless services supports this conclusion (see Figure V-1). In 2011wireless data revenues were about $70 billion with the expectation that they would exceed $90 billion in 2012 (and surpass voice revenues). With almost two thirds of the wireless data traffic being offloaded onto Wi-Fi and one third of the much larger amount of fixed broadband data being extended with Wi-Fi, the value of data traffic in the unlicensed space is not only well in excess of

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strategies exhibit because of the regulatory constraints that the protection of licensed services imposes on them—continuous coverage. It would allow open wireless strategies to fulfill the requirements of ever-more time- and space-sensitive applications. More basically, open wireless strategies have exhibited rapid innovation, filling services that only a few years ago would have been considered to require licensed exclusivity. The freedom to operate and innovate, by anyone for any purpose, that permission to operate without a license provides has allowed the kind of distributed, diverse innovation we have come to associate with computers and the Internet, more than the innovation model of more centralized models

$36 billion, but, more importantly, substantially larger than the value of wireless data traffic in cellular space.

EXHIBIT V-1: VALUE OF COMMERCE IN THE UNLICENSED SPACE

Global WiFi Value (Billion $/year) *	2011 Low	2011 High	2016 Low	2016 High
Extending Broadband	52.0	99.0		
Lower Cost of Cellular	30.0	93.0		
Internet of Things			1,400	2,200

Broadband Economy-wide Productivity Enhancement**	Billion $/year 2005	2016
Overall Productivity	18.4	73.0
Health Care	6.9	27.2
Field Service Apps.	4.1	16.5
Replace Desk Phones	0.2	4.9
Inventory Loss Reduction	0.9	3.6
Sales Force Automation	0.6	2.4
Total	13.1	127.6

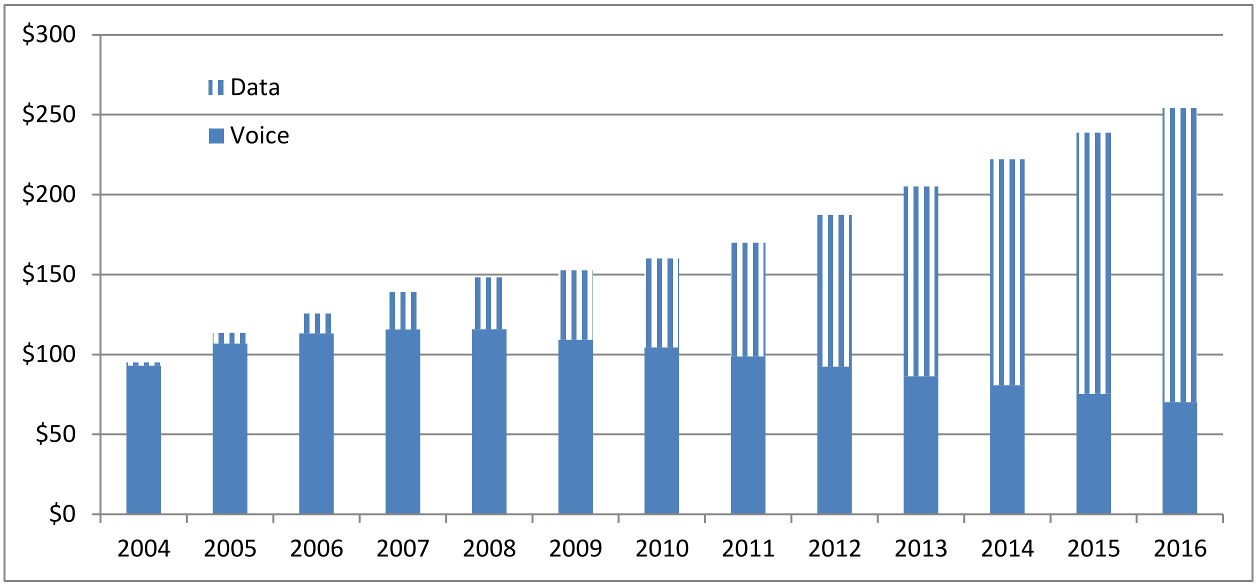
Productivity Gains from U.S. Wireless***

Activity	2011	2020
Energy Management	1.5	10
Sales & Inventory	6.1	25
Field Service & Wholesale	5.8	24
Medical	11.2	44
Security & Law	3	17
Financial & Payroll	0.8	7
Employment	4.2	81
Total	33	207

WiFi Applications, Services & Functionalities**	Value
Demand-side, End user	
Consumer Connectivity	
Direct	$5-15/user/mo.
Premium	$3-15/user/mo.
Video	$10-15/user/mo.
Embedded	$0.50/download
Business	
Business connectivity	$10-15/user/mo.
Machine to machine	$4/user/mo.
Targeted Mktng.	$100-150/Access Pt/mo
Managed hotspots	$50-$250/Access Pt/mo
Hosted small cells	$40-50/Access Pt/mo
Subletting	$50/Access Pt/mo
Supply –side, network operators	
Carriers	
Wholesale	
Offloading	$3-10/GB
Alternative Access	$2-5/GB
Roaming	$0.5-1/GB
Extended CDN	$0.01/GB
Productivity	
Bundling Reduced Churn	10-15%

Sources:*Richard Thanki, *The Economic Significance of License-Exempt Spectrum to the Future of the Internet,* June 2012; ** William Gerhardt, et al., *Profiting from the Rise of Wi-Fi: New, Innovative Business Model for Service Providers,* Cisco Internet Business Solutions Group, March 2012; ***Roger Enter, *The Wireless Industry: The Essential Engine of US Economic Growth,* Recon Analytics, 2011, p. 33

Figure V-1: U.S. Wireless Service Spending By Category



Source: TIA, 2012 *Market Review & Forecast*; with 2004 estimated based on CTIA, Semi-Annual Wireless Industry Survey.

B. THE MACROECONOMIC MULTIPLIER BENEFITS OF EXPANDED UNLICENSED ACTIVITY

When a technology or policy has such a broad impact on economic activity, efforts to assess the overall impact on the economy using input out models are inevitable. In the current economic environment, with high unemployment and slow growth, the macroeconomic impact of policy choices receives even greater of attention. The attention is expressed in dozens of articles that seek to assess the impact of in three areas – telecommunication and ICT generally,[58] broadband, in particular,[59] and wireless voice and data.[60]

[58] Lars-Hendrik Roller and Leonard Waverman, "Telecommunications Infrastructure and Economic Development," *American Economic Review,* September 2001; Anunsa Datta and Sumit Agwaral, "Telecommunications and Economic Growth: A Panel Data Approach," *Applied Economics,* 36 (2004); Bar van Ark, May O'Mahoney and Marcel P. Timmer, "The Productivity Gap between Europe and the United States: Trends and Causes," *Journal of Economic Perspectives,* 22:1 (2008); Dale Jorgenson, Mun S. Ho and Kevin J. Stiroh, "A Retrospective Look at the U.S. Productivity Growth Resurgence," *Journal of Economic Perspectives,* 22:1 (2008); Michael Poler, George van Leeuwen, Pierre Mohnen and Wladimir Raymond, *Productivity Effects of Innovation Modes,* Statistics Netherlands, 2009; Erik Brynolfsson and Adam Saunders, *Wired for Innovation: How Information Technology is Reshaping the Economy, MIT Press, 2010;* David Dean, et al., *The Internet Economy in the G-20: The 4.2 Trillion Growth Opportunity,* the Connected World, March 19, 2012;

These analyses cover national and local economies in general and also examine the productivity within firms and sectors. They strongly support the conclusion that increasing investment and activity in these areas increases economic growth, improves productivity and expands employment. Although there have been relatively little specific analysis of the role of spectrum availability specifically, the prospect of making spectrum available to increase the quantity and value of broadband activity is obviously attractive in this regard and has received a great deal.

These macroeconomic impact analyses tend to be complex bundles of assumptions that must be interpreted carefully. As an example, we consider a study commission by the CTIA. The CTIA study incorporated all of the elements that can be found in the literature. [61] It estimated the value of output in the sector and multiplied it to macroeconomic economic and employment effects

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Cay Area Economic Council Economic Institute, *Technology Works: High Tech Employment and Wages in the United States,* December 2012.

[59] Sharon Gillette, William Lehr, and Marvin Sirbu, *Measuring the Economic Impact of Broadband Deployment,* National Telecommunications Information Administration, February 28, 2006; S. K. Majundar, O. Carare and H. Chang, "Broadband Adoption and Firm Productivity: Evaluating the Benefits of General Purpose Technology," *Industrial and Corporate Change,* 19:3 (2009); Lynne Hold and Mark Jamison, "Broadband and Contributions to Economic Growth: Lessons from the US Experience," *Telecommunications Policy,* 33 (2009); Pantelis Koutroumpis, "The Economic Impact of Broadband on Growth: A Simultaneous Approach," *Telecommunications Policy,* 33 (2009); Irene Bertsche, Daniel Cerquera and Gordon J. Klein, "More Bits-More bucks? Measuring the Impact of Broadband Internet on firm Performance," *University of Manheim,* May 2011; Jed Kolko, *Does Broadband Boost Local Economic Development?, Public Policy Institute of California,* January 2010*;* Robert W. Crandall and Hal J. Singer, *The Economic Impact of Broadband Investment,* National Cable Telecommunications Association, February 23, 2010; Nina Czernich, et al., "Broadband Infrastructure and Economic Growth," *The Economic Journal,* 121: 552 (2011); Syed Muhammad Atif, James Endres and James Macdonald, *Broadband Infrastructure and Economic Growth: A Panel Data Analysis of OECD Countries,* 2012.

[60] Roger Enter, 2008, *The Increasingly Important Impact of Wireless Broadband Technology and Services on the U.S. Economy,* OVUM, 2008, *The Wireless Industry: The Essential Engine of US Economic Growth,* Recon Analytics, May 2012; Alan Pearce and Michael S. Pagano, "Accelerated Wireless Broadband Infrastructure Deployment: The Impact on GDP and Employment," *Media Law & Policy,* 18(2009); David W. Sosa and Marc Van Audenrode, *Private Sector Investment and Employment Impacts of Reassigning Spectrum to Mobil Broadband in the United States,* Analysis Group, August 2011; Deloitte, *The Impact of 4G Technology on Commercial Interactions, Economic Growth, and U.S. Competitiveness,* August 2011; Executive Office of the President Council of Economic Advisers, *The Economic Benefits of New Spectrum for Wireless Broadband,* February 2012; Capital Economics, *Mobile Broadband and the UK Economy: Rolling out 4G LTE Mobile Broadband, Improving Connectivity – Stimulating the Economy,* April 30, 212; Executive Office of the President President's Council of Advisors on Science and Technology, *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth,* July 2012.

[61] Roger Enter, The Wireless Industry: The Essential Engine of US Economic Growth, Recon Analytics, 2011.

and concluded with an estimate of the tax revenues that the sector generates. It added the novel feature of dividing the increase in economic activity attributed to wireless activity between 2004 and 2011 by the amount of spectrum auctioned over that period and converted the result into an estimate of the increase in economic activity that could be attributed to making 10 Mhz of spectrum available.

Putting aside the many assumptions that could be challenged, there are two aspects of the analysis that provide some insight. The estimate of economic activity is attributed to "wireless" and much of the discussion deals with voice, but over this period over five-sixths of increase in cellular carrier revenues came from wireless data (as shown in Figure III-1, above).

The study does not mention unlicensed spectrum, yet, as we have seen, four-fifths of the increase in wireless data traffic was offloaded to Wi-Fi over the period studied. Doing the math, it can be argued that half of the increase in economic activity should be attributed to unlicensed.

Since unlicensed adds at least as much value to fixed broadband, it can be argued that for every $1 of economic activity attributed to cellular wireless data, $2 of activity will be realized if an equal amount of spectrum is devoted to unlicensed spectrum. If auctioning 10 Mhz increases economic activity by $1.74 billion, not auctioning 10 Mhz (and dedicating it to unlicensed use) will generate $3.5 billion of economic activity.

C. THE REVENUE BENEFITS OF EXPANDED USE OF UNLICENSED SPECTRUM

This dramatic increase in economic activity leads directly to potential increases in employment and revenues. In fact, the study calculates the increase in both jobs and revenues that would be driven by the increase in economic activity. At the same time, the prospect of significant revenues that would result from auctioning additional spectrum is attractive given the large budget deficit.

The CTIA study estimated revenues based on the level of activity in the sector. Based on total revenues, the value of federal tax revenue generated by wireless activity equaled about $45 billion per year. The total annual federal revenues resulting from activity in the wireless space is about twice the expected revenues from the spectrum auction. The share that would be attributed to unlicensed is about $11 billion. With the estimates of economic activity flowing from the wireless space projected to grow dramatically over the next decade, the auction revenues are paltry compared to the general tax revenue on a growing stream of commerce.

Given the importance of unlicensed spectrum to the expansion of broadband activity, setting aside spectrum for unlicensed use would replace the "lost" action revenue in a matter of weeks or months. Setting aside spectrum for unlicensed use will result in large increases in total revenue not only because so much general revenue is generated,[62] but also because setting aside spectrum is not likely to have much impact on the auction revenues.

- First, if the supply of spectrum for exclusive licenses at auction is reduced, the cellular providers will bid up the price of the spectrum that is auctioned. Given the fact that the cellular service providers have declared a "spectrum crisis," it would be reasonable to assume that they will bid up the price substantially.[63]
- Second, because licensed and unlicensed have strong complementarity, the availability of unlicensed increases the value of licenses.[64]

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62 Milgrom, et al., 2011, p. 2, Yet, maximizing revenues often conflicts with the goal of creating a competitive market for wireless services. First, reducing the amount of available spectrum would typically increase auction revenue, but restrict the development of wireless services. Second, selling the rights to be a monopolist can raise much more revenue than selling license to many competing providers, to the detriment of post auction competition and efficiency."

63 Milgrom, et al, 2011, p. 23, "First, the reduction in the supply of spectrum is likely to increase the per unit price. If the aggregate demand for licenses is relatively inelastic… would by itself, actually increase the revenue that can be expected from a given auction. We are not aware of convincing estimates of the aggregate demand for licensed spectrum. Bulow, Levin and Milgrom (2009), however, have pointed out that in large spectrum auctions; the overall revenue tends to reflect the aggregate budgets of the participants. To the extent that telecommunications firms allocate budgets for spectrum purchases that are relatively insensitive to changes in available spectrum, and tend to spend their budgets at auction, changes in the available spectrum will have only modest effect, if any, on government revenue."

64 Milgrom, et. al., 2011, p. 23' "A second point is that complementarity between licensed and unlicensed spectrum can lead to a situation where unlicensed spectrum applications increase the demand for licensed spectrum applications and lead to higher license prices."

- Third, unlicensed spectrum increases the expansion of economic activity associated with the spectrum set aside for unlicensed use generates tax revenues at a higher tax rate than exclusive licenses because the purchase price of the spectrum is not claimed as a business expense.

Setting aside spectrum for unlicensed use is the best way to accomplish the goals of the reform and repacking of the spectrum that has been dedicated to broadcast TV.

> There are these three goals," said Neil Fried, chief counsel on technology on the House Energy and Commerce Committee: Obtaining the spectrum and auctioning it, creating jobs through its use and maximizing revenue. For that reason, Fried repeated Republicans' long-held view that there should be "few conditions on the spectrum" while the auction should be open.[65]

Unlicensed spectrum increases the value of activity in both the wireless broadband space and the fixed wireline space. It is the key to meeting many of the communications needs of the Internet of Things. By dramatically increasing economic activity and employment, it increases tax revenues. Moreover, as we have shown, unlicensed spectrum is such a successful driver of the economy precisely because it is free of the condition that kills entry and entrepreneurship, a license.

[65] Tony Romm, "Terry: FCC's spectrum auction all about raising $24 billion," January 9, 2013, http://leeterry.house.gov/index.php?option=com_content&view=article&id=2287:terry-fccs-spectrum-auction-all-about-raising-24-billion&catid=49